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Long-Run Productivity Shifts and Cyclical Fluctuations: Evidence for Italy

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Abstract

Using unobserved stochastic components and Kalman filter techniques, the paper assesses the relative importance of transitory and permanent shifts in Italian real GDP within a production function framework. Evidence suggests that the increase in hours worked that has accompanied pension and labor market reforms accounts for the bulk of low-frequency variation in growth, but points to factor utilization as the main driver of business cycle fluctuations. In contrast with the predictions of standard Real Business Cycle models, a positive shock to the underlying rate of total factor productivity growth generates a slight decline in hours, whereas the response of output to the same shock is found to be positive.

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I. Introduction

Standard Real Business Cycle (RBC) models have emphasized the role of exogenous stochastic changes in total factor productivity (TFP) as the only driving force of cyclical movements in macroeconomic aggregates.[2] Using some estimated autoregressive process as a proxy for exogenous shifts in TFP, these models have been able to replicate one key feature of the business cycle in industrial economies: the positive comovement between (band-pass filtered) output and hours worked.

More recently, several studies have questioned the empirical relevance of the technology-driven RBC hypothesis.[3] In particular, this literature has argued for the need to decompose productivity shifts associated with exogenous technological change from productivity shifts induced by other (non-technological) forces that may somehow affect the capital-labor ratio. Using a variety of identification techniques, these papers have shown that technology shocks (i) generate negative comovements between output and hours worked, and (ii) can only account for a small fraction of business cycle fluctuations.

A different, albeit related, issue for understanding the macroeconomic consequences of a shift in trend productivity growth concerns the role of imperfect knowledge about the permanent nature of such a shock. RBC models tend to assume that agents immediately recognize the nature of the shock and modify their expectations accordingly. However, in practice, sizable transitory fluctuations in productivity are likely to obscure agents' view of the underlying trend growth rate. Recently, a number of studies have emphasized how real-time expectations have a tendency to overemphasize the magnitude of slackness (inflationary pressures) in the economy during periods of decelerating (accelerating) trend productivity growth. The persistence of forecast errors relates to inherent lags in learning about shifts in the underlying rate of productivity, given the available information. Incorporating this expectation revision process is found to improve substantially models' ability to generate responses to productivity shifts that resemble historical experience.[4]

The goal of our paper is to assess the role played by long-run shifts in the underlying rate of technological change in accounting for Italy's 1990s productivity slowdown. To do that, we propose an innovative identification strategy. Using unobserved stochastic components and Kalman filter techniques, we assess the relative importance of transitory and permanent shifts to Italian output within a production function framework. The advantages of this estimation approach are manifold. Firstly, for each component under consideration, it allows for a very general (stochastic) data-generating process with unknown structural breaks. Indeed,

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[2] See, for example, Kydland and Prescott (1982), Cooley and Prescott (1995), King and Rebelo (1999).

[3] For a recent survey of the vast literature on the issue, see Galì and Rabanal (2004).

[4] See, for instance, Lansing (2000), Roberts (2001), and Edge, Laubach and Williams (2004).

macroeconomic aggregates such as average hours worked, employment, and labor participation feature low-frequency movements that are unrelated to the business cycle, but may be of relevance to understand the role of technology shifts in driving productivity changes. Getting input trends right is thus essential to this aim, as the lively debate about the stationarity of hours worked has recently shown.[5] Secondly—and unlike most of the empirical studies assessing how technology affects output and employment fluctuations—unobserved component models require the imposition of mild untestable restrictions for the identification of the shocks. Specifically, the only identification assumption used in our approach is that shocks to the transitory and permanent component of each aggregate follow independent and identically distributed processes. Thirdly, the proposed estimation technique allows for joint tests of hypotheses about the sources of long-run growth *and* business cycle fluctuations within a unified theoretical framework. The reliability of our estimates can thus be assessed using standard model diagnostics, whereas mutually consistent estimates for the equilibrium rate of unemployment and the rate of potential growth can be obtained as by-products. Last but not least, in the absence of real-time survey data for Italian labor productivity, the predictions of our estimated Kalman filter model provide a good proxy for agents' real-time forecasts of long-run productivity growth over the sample.

Results suggest that, even after correcting for variable factor utilization, the underlying rate of TFP growth—already on a downward slope for decades—slowed further over the 1990s. Potential growth declined from the 1970s until the mid-1990s, in line with a secular weakness in labor utilization and an enduring deceleration in TFP growth. Over the last decade, however, the trend component in hours worked has been drifting up—thanks to pension and labor market reforms—more than offsetting sluggish underlying factor efficiency. As a result, potential output growth has progressively recovered from the downfall of the early 1990s, even though productivity growth has tumbled.

A significant part of the disappointing productivity performance observed over the current downturn reflects, however, a contraction in factor utilization. Factor utilization is, indeed, found to account for the bulk of business cycle fluctuations and to be highly procyclical. Conversely, and in contrast with the predictions of standard RBC models, a positive shock to the underlying rate of TFP growth generates a slight *decline* in hours, although the corresponding response of output to the same shock is found to be positive. Results seem to be robust and essentially in line with recent findings for the euro area.[6]

The paper is organized as follows. The next section outlines the main stylized facts regarding trends in Italy's growth and productivity performance and investigates the factors behind

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[5] See, for example, Erceg and others (2005), Fernald (2004), Francis and Ramey (2004), and Galì (2004; 2005).

[6] Estevão (2004); Fabiani and Mestre (2001); Rünstler (2001); and Musso, Proietti, and Westermann (2002).

them. Section III presents Kalman filter estimates of the relative importance of transitory and permanent shifts to Italy's real output and discusses the effects and the role of technology shocks predicted by the model. Section IV concludes the paper by discussing the findings' implications for policy.

II. The Puzzle: What's Behind the 1990s Productivity Slowdown?

A. Stylized Facts

Italy's annual GDP growth averaged almost 6 percent in the 1960s, but fell below 2 percent in the 1990s. Breaking down GDP growth into labor, capital, and TFP contributions shows that the significant slowdown in real growth observed in Italy over the period 1960–2001 is explained almost completely by the decline in TFP growth—as measured by the Solow residual within a standard production function framework based on period averages of aggregate OECD data (Table 1A).[7] In particular, annual TFP growth has fallen from an average of 1.2 percent in the 1980s to an average of 0.6 percent over the 1990s—with a deceleration to a mere 0.2 percent after 1995.

Employment and average hours per employee have historically been a drag on growth. However, over the last decade, reforms to liberalize part-time and fixed-term labor contracts, tax incentives for permanent contracts, the creation of private employment agencies, pension reforms to discourage early retirement, and significant wage moderation have led to sizable increases in the employment ratio and in labor participation (Figure 1). As a result, the unemployment rate fell to 8.1 percent in 2004Q2 (seasonally adjusted)—below the euro area average—and labor factor services accounted for one-fourth of GDP growth over the second half of the 1990s. Nonetheless, hours per employee have continued to decline and the employment ratio remains—at 56 percent—the lowest in the euro area.[8]

Capital accumulation has reliably contributed to growth over time. In particular, since the 1980s, its contribution to annual GDP growth has fluctuated just above 1 percentage point, without losing pace in the second half of the 1990s. Recent labor market developments have resulted in a slight moderation in capital deepening after 1995, as measured by the rate of increase in the capital-labor ratio. However, the deceleration in capital deepening was modest and accounted for only one-third of the substantial fall in labor productivity growth.

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[7] This approach attributes real GDP growth to the contributions of three factors: growth of labor (proxied by the total number of hours) weighted by the labor income share in total domestic income, growth of capital (proxied by the capital stock) weighted by the capital income share, and TFP growth. In Table 1A, the calculations are based on aggregate OECD quarterly data for the business sector.

[8] Recent changes to the employment survey to bring it in line with EU norms have resulted in upward revisions to employment and, to a lesser extent, the labor force. Historical time series have been revised backward consistently.

The opposite movements of employment rates and labor productivity during the second half of the 1990s suggest that some of the recent decline in Italy's TFP may be related to the reentry into jobs of lower-productivity workers. As firms responded to labor market reforms by shifting to less capital-intensive production methods, a somewhat reduced rate of capital deepening had to be expected. Nevertheless, it is striking that the drop in the growth of TFP observed since the mid-1990s has been so sharp as to neutralize most of the positive contribution to growth from the increase in labor supply that has accompanied structural reforms.

The exceptional sluggishness observed in TFP growth raises a number of questions. Does the Solow residual strictly measure Hicks-neutral technological changes? Otherwise, what has been driving an equal deceleration in the marginal productivity of all factor inputs over the last decade?

B. Hypotheses

Many studies have looked into the factors accounting for Italy's productivity slowdown over the 1990s. Among the explanations offered are the following:

- *Mismeasurement of factor quality changes.* Estimates of TFP growth are often used to proxy technological progress. They are obtained as the residual output growth once the weighted contributions of changes in capital and labor inputs are accounted for. Therefore, TFP growth estimates involve a number of assumptions concerning the measurement of output and inputs.

    - In the case of capital, quantities and prices should be adjusted for changes in quality. Table 1B shows growth decomposition results using available annual data from the Italy-specific *total economy* Groningen Growth and Development Center (GGDC) database, which takes into account price and quality changes in different categories of capital (for convenience grouped here into information technology, IT, and non-IT). Compared with results obtained using unadjusted OECD data (Table 1A), it appears that quality improvements in capital are indeed absorbed by the Solow residual, roughly accounting for some 0.1 percent of TFP growth throughout the sample (Figure 2A). However, changes in the quality of capital do not seem to be able to explain the fall in productivity growth characterizing the second half of the 1990s.

    - In the case of labor, changes in skills and educational attainment need to be explicitly taken into account. Brandolini and Cipollone (2001) adjust the labor contribution to value-added growth in Italy's industrial sector by correcting for changes in the composition of the employed labor force using wage differentials, as well as effective hours worked and capacity utilization. Overall, they find that a sizeable part of the Solow residual vanishes after the adjustment, although the latter is not sufficient to overturn the evidence of a productivity slowdown in the second half of the 1990s (Figure 2B).

- Measures of growth rates of TFP can also be sensitive to aggregation methods. This may be the case particularly when quantities and user costs of some disaggregated inputs evolve along different patterns than those of the aggregate. This is the case, for example, when quality improvements in some particular capital inputs (such as IT) are faster than those in others. A measure of TFP growth that fully accounts for changes in the composition and quality of both labor and capital inputs captures "disembodied" technological and organizational improvements that increase output for a given amount of inputs. Table 1C reports results from a very recent study looking at this issue using Italian data:[9] once compositional and quality changes are properly measured, TFP is left to explain less than ¼ of output growth. However, on average, compositional changes in capital accumulation seem to play a limited role—another 0.1 percent—in explaining the recent productivity deceleration in the Italian economy.

- Improvements in the quality of capital and labor may also have boosted productivity in industries and countries that have invested in them. For example, the shift towards IT assets—whose relative prices have been falling—implies that with the same amount of resources it is possible to acquire a greater amount of productive capital services. This suggests that there is also an "embodied" element of technological change due to the expansion of the productive capacity from the shift toward IT assets.[10] Bassanetti and others (2004) estimate that the major contribution to Italy's TFP growth over 1981–2001 has come from the service sector—in particular transport, communication, and financial intermediation—where the IT capital accumulation has been the largest. Net of "embodied" technological change—the authors conclude—the productivity slowdown in the second half of the 1990s would have been even larger.

- *Variable factor utilization.* Solow's (1957) original contribution presumed that variations in capacity were a major reason for the procyclicality of measured productivity, a presumption widely held thereafter.[11] In essence, the problem is one of *cyclical mismeasurement*: true inputs services are more cyclical than measured inputs services. As a result, productivity—as measured by the Solow residual—is spuriously cyclical. Within a cost-minimizing framework with quasi-fixed capital and labor inputs, variable factor use is generally due to swings in marginal factor costs: as expansion proceeds, firms can cut back on costly utilization margins by increasing

[9] Bassanetti, Iommi, Jona-Lasino, and Zollino (2004).

[10] See, among others, Greenwood, Hercowitz, and Russell (1997) and Hercowitz (1998).

[11] See, for instance, Abbott, Griliches, and Hausmann (1998); Basu (1996); and Basu and Kimball (1997).

hours via overtime.[12] According to this hypothesis, the (enduring) decline in labor productivity over the second half of the 1990s may reflect a fall in the steady-state marginal cost of labor. If, at the margin, hiring labor has become particularly cheap, firms will work existing employees for shorter periods (decreasing observed hours per worker) and less strenuously (thereby decreasing unobserved productivity).

- *Distortions and markets imperfections.* Productivity and technology may also differ because of distorsions—such as imperfect competition, the presence of increasing returns, etc. In general, if firms are not all perfectly competitive, then it is not appropriate to use a standard production function framework and, consequently, to use the Solow residual as measure of exogenous technology shifts, since the Solow residual becomes endogenous.[13] Following are few examples of distortions and imperfections characterizing the Italian market structure, whose effects on factor efficiency might have been incorrectly captured by measures of the Solow residual.

    - Relatively high tax ratios, deemed to have undercut Italy's growth performance by discouraging labor supply and investment;[14]

    - A heavy regulatory burden in labor and product markets and bureaucratic red tape, likely to have hampered competition and stifled incentives to invest;[15]

    - The resilience of the intrasectoral structure of the Italian economy, echoing an inability to reallocate resources towards sectors with higher-than-average factor productivity;[16]

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[12] As stressed by Basu, Fernald, and Kimball (2004), quasi-fixity is necessary to justify variable factor utilization. Higher utilization must be more costly to the firm, otherwise factors would always be fully utilized. It is thus generally assumed that the major cost of increasing capital utilization comes from the fact that firms must pay a shift premium to compensate employees for working at undesirable times. At the same time, it must be costly to increase the rate of investment or hiring, otherwise firms would always keep utilization at its minimum level and vary inputs using only the extensive (rather than intensive) margin.

[13] Indeed, in case of non-zero markups of price over marginal costs, payments to factors that receive the profits will exceed their cost. Solow's factor shares—the payments to each factor divided by total revenue—will therefore correspond to output elasticities if and only if the firms makes zero profits. See Rotemberg and Woodford (1995) for a survey of dynamic general equilibrium models with imperfect competition.

[14] See, for example, ISAE (2003) and references therein.

[15] The papers in ISAE (2001 and 2004) examine in detail the impact of the quality of the business environment on growth.

- A large share of small and medium-size enterprises, which might have hobbled productivity growth by limiting the scope for economies of scale and technology transfers.[17]

A rigorous analysis of the mechanisms triggering suboptimal productivity performances in Italy over the last decade is clearly beyond the focus of this paper. We limit the analysis to arguing that any reasonable explanation of the productivity puzzle should account for key stylized facts across four dimensions, namely: (i) the cross-country dimension, e.g., changes in comparative performances with respect to other industrial countries; (ii) the cross-sector dimension, e.g., changes in comparative performances across inputs and product markets; (iii) the structural dimension, e.g., changes in macroeconomic responses to underlying shifts in the economy; and (iv) the cyclical dimension, e.g., changes in business cycle comovements among relevant aggregates.

Considering the vastness of the problems raised in this section, the focus of the rest of this paper is modest. The next section is a first attempt to explore dimensions (iii) and (iv) of Italy's productivity puzzle. The approach is agnostic. To measure the relative importance of structural and cyclical components in explaining productivity variations, we will use a multivariate unobserved component model of the production function. Within such a (Bayesian) growth accounting framework, we will be able to decompose (permanent) shifts to (stochastic) factor input trends from cyclical fluctuations in their stationary components. As a result, the Solow residual can be corrected by the presence of significant procyclical error and used as a measure of technology, while business cycle comovements among macroeconomic aggregates of interest—such as output and productivity, output and hours, and productivity and hours—can be jointly analyzed.

III. The Pieces: The Use of Unobserved Components for Growth Accounting

A. The Business Cycle Revisited

Real Business Cycle macroeconomics traditionally identifies aggregate business cycle fluctuations with "those movements in the series associated with periodicity within a certain range of business cycle duration."[18] In conformity with the classical National Bureau of Economic Research definition of business cycle, this range of business cycle periodicities is assumed to be between 6 quarters and 8 years. Drawing on the theory of spectral analysis, Baxter and King (1999) proposed a univariate two-sided moving average filter able to "extract" from the data only fluctuations within this range of frequency—the Baxter-King

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[16] Bugamelli and Rosolia (2004) and other papers in Banca d'Italia (2004) look at the relation between industrial structure, efficiency, and competitiveness of Italian firms over the 1990s.

[17] See, for example, the papers in ISAE (2003 and 2004) and references therein.

[18] Stock and Watson (2000).

filter. In this way, both high-frequency fluctuations (lasting less than 6 quarters and mainly associated with measurement errors and seasonality) and low-frequency fluctuations (lasting more than 8 years and possibly associated with variations in trend growth) are removed from the data.[19] On this ground, macroeconomic series are decomposed into irregular, cycle, and trend components, respectively corresponding to the high, business cycle, and low frequency parts of the spectrum.

Spectral density analysis reveals that the Italian business cycle is characterized—on average—by 4½ years duration, just slightly shorter than the 5-year business cycle typifying the euro area.[20] The standard deviation of output is estimated at 1.35 percent, suggesting that the Italian business cycle is somewhat more volatile than the euro area's (0.84 percent), but comparable to that of the United States (1.34 percent).[21] Over the sample period, trough-to-peak expansions have an estimated average duration of 13 quarters and are longer than recessions, with 9-quarter average duration. This asymmetry is quite common in postwar data for industrial countries and it is generally associated to positively sloped output trends. Dating the business cycle indicates that the most severe recession occurred over the period 1974Q1–1975Q3 followed, in terms of amplitude, by those in 1963Q4–1965Q1, 1980Q2–1983Q1, and 1969Q1–1972Q4. The recessions of 1990Q1–1993Q3 and 1976Q4–1977Q4 had somewhat smaller amplitude.

Although its cycle was highly synchronized with that of the euro area throughout the sample period, Italy experienced much larger fluctuations in the 1970s. This is likely due to the heavy Italian reliance on imported oil. The Italian fluctuations subsequently decreased, as the share of energy-related imports declined (by around 40 percent) during the 1980s. However, as is the case for other industrial countries, the fall in volatility of fluctuations experienced in Italy since the mid-1980s may also be the result of a combination of other factors, such as better policies and shifts in output composition.[22]

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[19] The ideal filter would require an infinite number of past and future values of the series. We truncate the band pass filter (e.g., the two-sided moving average) with 12 lags and leads, thereby reproducing the optimal finite-order approximation suggested by Baxter and King (1999). In this way, the first and last 12 observations of the series are automatically lost.

[20] Results for the euro area refer to Agresti and Mojon's (2001) findings.

[21] While we report results using data from 1960Q1, Agresti and Mojon (2001) compare stylized facts for the US and the euro area cycles using a shorter sample period, starting in 1970Q1. However, dropping the sixties from our sample does not seem to affect much reported properties of the Italian business cycle.

[22] Blanchard and Simon (2001) show that there is a strong correlation both between output volatility and the level of inflation and between output volatility and inflation volatility across G-7 countries. Stock and Watson (2002) question the hypothesis that "great

(continued…)

Comovements—as expressed by correlations among band-pass filtered aggregates—between the overall business cycle and corresponding fluctuations in labor market indicators show that aggregate employment, average hours worked, capacity utilization, and labor productivity are strongly procyclical (Table 2). Interestingly, this is also true for participation in the labor market, a component that is hardly assumed to be subject to short-run shifts. Employment, labor force, and labor participation lag the business cycle, whereas capacity utilization and labor productivity are coincident with it. There is also evidence that movements in the number of hours worked per employee in the business sector are a genuine predictor of the Italian business cycle, leading the cycle by approximately one quarter. In contrast, fluctuations in unemployment rate are only weakly countercyclical and lag the cycle by one year. Preliminary data analysis hence provides some evidence in favor of the existence of short-term frictions in the labor market—a hypothesis that justifies swings in labor efficiency to echo the business cycle, as firms would employ a more-than-optimal number of workers for a given decline in production.

Nonetheless, productivity responses in the current (i.e., post-2001) downturn seem to signal a greater degree of idling capacity with respect to productivity responses observed over the 1992–93 recession. Over the first half of the 1990s, the drop in total hours worked (and the reduced contribution from capital) more than offset the contraction in growth, while average hours work remained roughly unchanged. Labor efficiency actually *rose*, as adjustments in the labor market occurred via downward shifts in the *supply* of labor. Over the recent slowdown, however, labor productivity has dropped sharply, with declines in average hours and spare capacity carrying the burden of the adjustment in the labor market. Such a correction, however, has not been sufficient (so far) to offset the exceptional upturn in labor supply resulting from structural factors such as the effects of pension and labor market reforms, wage moderation, and the emergence of the underground economy.[23] However, given that two-sided moving average filters are inapt to characterize economic developments after 2001, evidence of cyclical fluctuations over the recent slowdown has remained—so far—anecdotical.

B. The Production Function Approach Revisited

In order to evaluate the relative importance of short-run variations in the degree of factor utilization and permanent technology shifts in explaining recent changes in TFP, we adopt an

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moderation" in G-7 countries is a byproduct of improved monetary policy, while suggesting that more than half of the decline in output volatility is the result of smaller common international shocks. Other possible causes identified by the literature for the output volatility decline include improvements in inventory management (McConnell and Pérez-Quirós, 2000) and shifts in output composition (Alcalá and Sancho, 2004).

[23] The effects of an underground economy within a real business cycle model are analyzed in Busato and Chiarini (2004) and Conesa, Diaz-Moreno, and Galdon-Sanchez (2002).

innovative identification strategy hinging upon the use of unobserved components (UC) within a production function framework. The rationale is to obtain estimates of potential output and underlying productivity growth from the trend components of TFP and factor inputs. The attractiveness of the UC approach lies in the fact that it combines positive aspects of purely statistical and purely structural estimation methodologies. Moreover, it does not suffer from the end-point problem, as the filters implicitly defined by the model automatically adapt to the end of the sample.

In considering a specification of the technology which allows for variable capital utilization, we assume a quite flexible production function:

$$Y_t = A_t (C_t L_t)^{\beta} (C_t K_t)^{1-\beta} \tag{1}$$

Here, technology has the usual Cobb-Douglas representation with constant returns to scale and perfect market competition.[24] Hence, β is the labor share—measured by the cost of labor services as a share of total costs—A represents total factor productivity, L denotes total hours worked in the economy, K is the capital stock, and C is the unobserved degree of capacity utilization—ranging over the interval (0,1]—both labor and capital are adjusted for.[25] Taking logs of both sides of equation (1)—here denoted by small caps—yields:

$$y_t = \left(a + c\right) + \beta l_t + (1-\beta) k_t \tag{2}$$

All factor inputs in equation (2) can be additively decomposed into their (unobserved) permanent (denoted by superscript star) and cyclical (denoted by superscript *c*) components, with the exception of the capital stock, which is assumed to be fully permanent and, hence, to contribute only to potential. While the permanent component of the Solow residual (a^*) is

[24] In the model we have in mind, all the nontechnological effects (e.g., nonconstant returns to scale, imperfect competitions, and input reallocations) considered by Basu, Fernald, and Kimball (2004) and briefly discussed in Section II, do not operate in the long run, so that over long horizons, productivity is solely driven by technology. In particular, whenever a shock increases demand, the increase in production would mandate higher output per firm and would lead to increases in profits. This would spur entry and drive per firm output and profits down to zero. By the same token, in order for increasing returns to contribute to long-run productivity growth, firms should expand their scale of operation, thereby reducing unit costs forever. This is impossible, as scale economies would be reduced as new firms enter the market and per-firm output falls. Nontechnological effects would, however, operate over the short run and would therefore be part of the cyclical component of the Solow residual.

[25] Basu and Kimball (1997) show that if the sole cost of changing the workweek of capital is that workers need to be compensated for working at night, then one can use a single proxy for changes in *both* effort and capital utilization.

solely driven by technology, the transitory component of the Solow residual (a^c) is likely to absorb all nontechnological effects to productivity as well as fluctuations in the intensity of capital use. As such, the stationary component of the Solow residual is likely to display more business cycle variability than strictly defined TFP. Algebrically:

$$\begin{aligned} \tilde{a} &\equiv (a+c) = a^* + a^c, \\ l &= l^* + l^c, \\ k &= k^*. \end{aligned} \tag{3}$$

The log of total hours (*l*), in turn, can be additively decomposed into its determinants, e.g., working-age population (*wpop*), participation ratio (*pr*), the unemployment rate (*u*), and the average number of hours per employee (*h*).[26] These determinants can be also disentangled into their own permanent and cyclical components, so that the permanent and cyclical labor contributions can be written as:

$$\begin{aligned} l^* &= wpop + pr^* - u^* + h^*, \\ l^c &= pr^c - u^c + h^c. \end{aligned} \tag{4}$$

The intuition is that population dynamics are fully permanent, whereas labor force participation, employment, and average working hours contain also cyclical information.

Combining identities (2)-(3)-(4) yields a multivariate UC model for output decomposition. Specifically, the model consists of a measurement equation for real output, e.g.:

$$y_t = \beta wpop_t + (1-\beta)k_t + \begin{bmatrix}1 & \beta & -\beta & \beta\end{bmatrix}\boldsymbol{\mu}_t + \begin{bmatrix}1 & \beta & -\beta & \beta\end{bmatrix}\boldsymbol{\psi}_t, \tag{5}$$

where the unobserved permanent and transitory components are denoted by $\boldsymbol{\mu}_t = \begin{bmatrix}a^* & pr^* & u^* & h^*\end{bmatrix}'$ and $\boldsymbol{\psi}_t = \begin{bmatrix}a^c & pr^c & u^c & h^c\end{bmatrix}'$, respectively. The transition system describing the dynamics of such stochastic unobserved components is given by:

$$\begin{cases} \boldsymbol{\mu}_t = \boldsymbol{\mu}_{t-1} + \boldsymbol{\kappa}_{t-1} + \mathbf{v}_t^{\mu}, & \mathbf{v}_t^{\boldsymbol{\mu}} \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Sigma}_{v^{\mu}}), \\ \boldsymbol{\kappa}_t = (\mathbf{I}-\mathbf{P})\boldsymbol{\kappa}^* + \mathbf{P}\boldsymbol{\kappa}_{t-1} + \boldsymbol{\omega}_t^{\kappa}, & \boldsymbol{\omega}_t^{\boldsymbol{\kappa}} \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Sigma}_{\omega^{\kappa}}), \\ \boldsymbol{\psi}_t = \boldsymbol{\tau}\varphi(L)ip_t + \boldsymbol{\varepsilon}_t^{\Psi}, & \boldsymbol{\varepsilon}_t^{\Psi} \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Sigma}_{\varepsilon^{\psi}}). \end{cases} \tag{6}$$

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[26] To maintain log-linearity, while enabling modeling the NAIRU, we use the first-order Taylor approximation for the employment rate, so that $e_t = \ln(1-u_t) \approx -u_t$.

where the reference cycle—an autoregressive process of second order $\varphi(L)$ that is here constrained to be common across factor inputs—is assumed to be driven by fluctuations in the industrial production index, *ip*. The four transitory components in vector $\boldsymbol{\psi}_t$—e.g., the Solow residual, a^c, the participation ratio, pr^c, the unemployment rate, u^c, and the average hours, h^c—can in turn be expressed as linear combinations of current and lagged values of the reference cycle, given the matrix of loading parameters, $\boldsymbol{\tau}$. Corresponding factor inputs trends—denoted by vector $\boldsymbol{\mu}_t$—are assumed to follow random walk processes with stochastic drifts—denoted by vector $\boldsymbol{\kappa}_t$. The growth rate of each factor trend can thus take a different shape, depending on the value of the corresponding element in the matrix $\boldsymbol{P}$. For instance, if the first element in $\boldsymbol{P}$ is estimated to be insignificantly different from 1, then TFP would be an integrated series of second order. Else, if $0<P_{1,1}<1$, the time-varying TFP growth rate would converge back to a steady-state rate, κ_1^*.

$\boldsymbol{\varepsilon}_t^{\boldsymbol{\psi}}, \mathbf{v}_t^{\boldsymbol{\mu}}$, and $\boldsymbol{\omega}_t^{\boldsymbol{\kappa}}$ denote the vectors of shocks to the cyclical components, the factor trends, and the trend growth rates, respectively. The shocks are assumed to follow independent identically distributed processes, with error covariance matrices $\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}, \boldsymbol{\Sigma}_{\mathbf{v}}$, and $\boldsymbol{\Sigma}_{\boldsymbol{\omega}}$, respectively. The dynamics of permanent and transitory components depend on the nature of the shocks, that is, on the relative importance of supply and demand shocks.[27] This relative importance, which determines the smootheness of the trend component, is the ratio of the variance of the cycle to the variance of the trend fluctuations. A small ratio implies that shocks are mainly supply shocks, where trend inputs moves nearly with observed data, and hence a small business cycle component is to be expected. On the contrary, a larger weight on the smoothness of the trend means that shocks to the economy are primarily shocks to aggregate demand. Such a parameter can either be selected a priori—as it is with Hodrick-Prescott filters—or jointly estimated with other parameters of the model—as it is the case with UC models. In this sense, UC model-based detrending techniques somewhat encompass HP filtering.

Once the model (5)-(6) is cast in the state space form, the Kalman filter and the associated smoothing algorithm enable maximum likelihood estimation of the model parameters and signal extraction of the unobserved components, conditional upon a set of initial parameters and the appropriate information set. More specifically, the *basic filter* provides an estimate of the unobserved state vector conditional upon the information available up to time t. The smoothing provides a more accurate estimate on the vector, by using all the available information in the sample through time T. Under the assumptions of model linearity and Gaussian disturbances, the *conditional distribution* of the observed variables—e.g., real GDP and unemployment—is also Gaussian. As such, the sample log-likelihood function can be maximized with respect to the unknown parameters of the model and the set of parameters can be estimated using a maximum-likelihood estimator. Iterating the basic filter starting

[27] By construction, demand and supply shocks are assumed to be orthogonal.

from t=1 to T, while evaluating the log likelihood function from observation τ+1 (where τ is large enough) to T, minimizes the effects of some arbitrarily chosen initial values on the log-likelihood value. On the other hand, the last iteration of the basic filter provides the initial values for the smoothing.[28]

Table 3 reports estimates and standard errors of the model parameters, equation diagnostics, and the predicted final state for potential growth, the output gap, and the NAIRU for three different model specifications using quarterly data over the period 1960:1-2004:2. The Kalman filters start, however, in 1970:2. The model in the first column assumes a fixed labor income share derived from national accounts and does not control explicitly for capacity utilization; the model in the second column allows for ISAE's survey-based index of capacity utilization to shape the transition equation for cyclical TFP; the model in the last column controls for capacity utilization and allows for the labor income share to be freely estimated. Given the similarity of the third and second models, results for the third model are not discussed. Estimates of the implied rate of technological growth—as proxied by the drift component of the Solow residual with and without control for capacity utilization—are reported in Figure 3 (panels A and B). Graphic analysis of one-step-ahead forecast errors (only for the model with control for capacity utilization) is provided in Figure 4.

Estimates of the unrestricted univariate model (not reported) provide a poor representation of the Italian business cycle, featuring very short autoregressive cycles in factor inputs with small disturbance variance coupled with nonstationary and highly volatile drifts. Restricting the variance of the drift to zero reduces input trends to random walk processes with constant drifts (also not reported)—a specification consistent with the stationarity of the GDP growth rate, but strongly rejected by the data, given that $\boldsymbol{P}$ is found to be insignificantly different from an identity matrix. We hence restrict the variance of the trends to zero (Table 3, first column), so that potential input levels become local linear trends (and so does potential output), with trends shifts fully captured by changes in their slopes, which are assumed to evolve smoothly over time.

Results indicate that the rate of technological change—already on a downward slope for decades—has declined further over the 1990s (Figure 3A). Potential growth, on the contrary, is found to have progressively recovered from the end of 1993 to the end of 2001, rising from an annual rate of 0.7 percent at the end of the 1992–93 recession to over 2 percent just before the current slowdown—a growth rate analogous to that of the early 1990s (Figure 3B). The structural behavior of potential growth and TFP growth is hence found to be markedly different, while comoving over the cycle. The existence of a constant wedge between trend growth in labor and in TFP confirms the idea that the rate of capital deepening has remained stable over time, at around 1 percent.

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[28] For a thorough exposition of the state space methodology, the reader may refer to Harvey (1989) and Kim and Nelson (1999). Estimation was carried out in Gauss 6.0.

At the end of the sample, potential growth is estimated to be around 1¼ percent, with output being below potential by 1 percent. The output gap is estimated to follow a stationary second-order autoregressive process, with roots equal to 1.27 and -0.41 respectively, yielding a cycle with a period of over four years. Uncertainty around the estimates is high, with predictive standard errors of 0.9 percent. Out of total uncertainty, about two-thirds is due to uncertainty about disturbances, whereas only one-third is associated with parameter uncertainty. The fit is generally satisfactory and, once capacity utilization is accounted for, there is no evidence of significant misspecification (Figure 4).

Overall, cyclical fluctuations in productivity and factor inputs load on the common cycle with expected signs. Crucially, controlling for capacity utilization substantially reduces the role of technology in accounting for cyclical fluctuations in real output.[29] In particular, when we *do not* control explicitly for movements in capacity utilization (Table 3, first column), the cyclical component of TFP is found to move remarkably in line with the business cycle, with estimates indicating that a 1 percent increase of output above potential would rise productivity by over 0.6 percent. In addition, the variance of its cyclical component is found to be over seven times as large as the variance of its permanent component and to account for almost all the cyclical variation in output. Interestingly, however, if one controls for shifts in capacity utilization (Table 3, second and third columns), the contemporaneous correlation of the cyclical component of productivity with the business cycle halves and its variance drops dramatically, becoming insignificant. In other words, data seem to suggest that short-run fluctuations in TFP are fully captured by variable factor utilization. In all model specifications, the unemployment rate is found to be weakly (though significantly) countercyclical and—consistently with previous estimates—to fall just by 0.04 as ouput rises 1 percent above potential. Short-run variations in labor participation and average hours worked are broadly a-cyclical.

C. The Role of Productivity Shocks

Thanks to the original identification methodology employed, our Kalman filter estimates allow direct examination of the effects of productivity shocks. Specifically, we use estimated drift components for factor inputs and technology to assess potential and hours growth responses to permanent productivity shifts (Figure 5), while responses to transitory shifts in productivity can be analyzed by focusing on estimated impulse responses of the stationary component of factor inputs and TFP (Figure 6).

In contrast with the predictions of standard RBC models, a positive technology shock is found to generate a negligible long-run *decline* in hours growth. The corresponding response of potential growth to the same shock is, on the contrary, always positive (Figure 5).

[29] To highlight these differences, relevant estimated parameters are reported in bold in Table 3.

Evidence seems hence to point to nontechnological factors as the main driver of positive business cycle comovements between hours and output (Figure 6).

Interesting information can also be extracted by decomposing the covariance matrices of output trend slope and its cyclical component. The bulk of the permanent variation in output is found to be driven by shifts in labor trends (Figure 7), namely employment (which explains around 40 percent of long-run movements in growth) and labor participation (which accounts for around 30 percent of shifts in potential growth). Conversely, the Solow residual appears to absorb approximately 60 percent of the cyclical variation in real GDP (Figure 8). In other words, changes in employment growth are likely to respond very little to business cycle fluctuations, which have been largely associated with transitory nontechnological shifts, such as variable factor utilization.

IV. Concluding Remarks

We started this paper by noting that decomposing productivity shifts associated with long-run technological change from productivity shifts induced by other (nontechnological) forces is essential to understand the role of technology shifts in driving productivity growth. We then developed an estimation strategy to decompose low-frequency movements in Italy's average hours worked, employment, and labor participation from long-run shifts in the country's TFP, while assuming imperfect knowledge about the permanent nature of these shocks. Within this framework, we explicitly controlled for variable capacity utilization to assess its role in accounting for cyclical fluctuations in Italian productivity.

From an empirical perspective, the paper reveals that in Italy the rate of technological change has been on a downward slope for several decades. A sizeable part of the Solow residual observed over the 1992–93 recession vanishes after adjusting for cyclical factors, although the adjustment actually reinforces the evidence of a further slowdown in Italy's trend TFP growth over the 1990s. The paper also provides new evidence that the major source of potential growth variation is likely to be associated with changes in employment growth, confirming the structural nature of recent Italian labor market dynamics. Conversely, technology shocks are not found to generate the strong and positive comovement between GDP and hours growth that proponents of the RBC paradigm have led us to expect. Shifts in factor utilization, instead, seem to explain the bulk of business cycle fluctuations, while inducing positive shifts in *both* output and hours worked over the short run.

From a normative viewpoint, this paper's analysis carries noteworthy policy implications. It stresses the importance of addressing not only factors preventing further employment growth, but also those constraining factor efficiency. Evidence of stagnant and procyclical productivity growth may support the hypothesis of a (negative and persistent) demand shock within an economy featuring sustained wage moderation.[30] At the same time, however, the enduring sluggishness in factor efficiency may conceal the need to reduce distortions in product markets, including inadequate competition in key sectors and overhead costs. The negative link between long-term productivity performance and the degree of frictions and imperfections in the economy—such as imperfect competition or costs of reallocating inputs—has been widely recognized by the literature both on theoretical and empirical grounds.[31] Further research is, however, warranted to assess whether this channel could explain the significant slowdown in Italy's productivity growth in recent decades.

[30] In Italy, the share of fixed-term contracts among new hires grew from 34 to 42 percent between 1995 and 2003. Cipollone and Guelfi (2004) evaluate that the labor cost reduction associated with this expansion amounted to about 16 percent.

[31] For theoretical models linking distorsions to productivity performances, see among others, Rotember and Woodford (1991), Ramey and Shapiro (1998). OECD (2003) presents interesting cross-country evidence on the issue.

Table 1A. Growth Accounting: Period Averages

Looking at contributions to growth...

	Labor	Labor: Avg. hours worked in business sector	Labor: Share of Labor in Business Sector	Labor: Employment	Labor: Labor force	Labor: Population	Capital	TFP	GDP
61-70	-0.9%	-0.4%	-0.2%	0.0%	-0.7%	0.4%	1.9%	4.8%	5.7%
71-80	-0.5%	-0.6%	-0.4%	-0.1%	0.2%	0.4%	1.4%	2.8%	3.6%
81-90	0.2%	-0.2%	0.2%	-0.3%	-0.2%	0.5%	0.9%	1.2%	2.3%
91-01	0.0%	-0.2%	0.0%	0.0%	0.0%	0.1%	1.1%	0.6%	1.7%
of which:									
81-85	-0.2%	-0.4%	0.3%	-0.5%	-0.4%	0.8%	0.9%	1.0%	1.7%
86-90	0.5%	0.1%	0.2%	-0.1%	0.1%	0.2%	1.0%	1.3%	2.9%
91-95	-0.9%	-0.3%	0.2%	-0.4%	-0.5%	0.1%	0.9%	1.2%	1.3%
96-01	0.5%	-0.2%	0.0%	0.2%	0.5%	0.0%	1.2%	0.2%	1.9%
61-01	-0.3%	-0.4%	-0.1%	-0.1%	-0.1%	0.3%	1.3%	2.3%	3.3%
71-01	-0.2%	-0.3%	0.0%	-0.1%	0.0%	0.3%	1.2%	1.5%	2.5%
81-01	0.0%	-0.2%	0.1%	-0.1%	0.0%	0.3%	1.0%	0.9%	1.9%
91-01	0.0%	-0.2%	0.0%	0.0%	0.0%	0.1%	1.1%	0.6%	1.7%

Source: OECD data and authors' calculations.

Looking at capital deepening...

	Capital Deepening	TFP	Labor Productivity
61-70	2.3%	4.8%	7.1%
71-80	1.7%	2.8%	4.4%
81-90	0.9%	1.2%	2.0%
91-01	1.1%	0.6%	1.7%
of which:			
81-85	0.9%	1.0%	2.0%
86-90	0.8%	1.3%	2.1%
91-95	1.4%	1.2%	2.6%
96-01	0.9%	0.2%	1.1%
61-01	1.5%	2.3%	3.8%
71-01	1.2%	1.5%	2.7%
81-01	1.0%	0.9%	1.9%
91-01	1.1%	0.6%	1.7%

Source: OECD data and authors' calculations.

Table 1B. Growth Accounting: Adjusting for Factor Quality Changes

Looking at contributions to growth...

	Labor	Capital	Capital: IT	Capital: Non-IT	TFP	GDP
61-70	...	...	...	...	...	...
71-80	...	...	...	...	...	...
81-90	0.4%	1.1%	0.3%	0.8%	0.6%	2.2%
91-01	0.1%	1.1%	0.3%	0.8%	0.4%	1.6%
of which:						
81-85	0.2%	1.0%	0.3%	0.7%	0.4%	1.6%
86-90	0.7%	1.3%	0.4%	0.9%	0.9%	2.8%
91-95	-0.7%	0.9%	0.2%	0.6%	1.0%	1.2%
96-01	0.5%	1.3%	0.4%	0.9%	0.2%	1.9%
61-01	...	...	...	...	...	...
71-01	...	...	...	...	...	...
81-01	0.2%	1.1%	0.3%	0.8%	0.6%	1.9%
91-01	0.1%	1.1%	0.3%	0.8%	0.4%	1.6%

Source: Timmer, Ypma, and van Ark (2003) and authors' calculations.

Looking at capital deepening...

	Capital Deepening	Capital Deepening: IT	Capital Deepening: Non-IT	TFP	Labor Productivity
61-70	...	...	...	...	...
71-80	...	...	...	...	...
81-90	0.9%	0.3%	0.6%	0.6%	1.6%
91-01	1.1%	0.3%	0.7%	0.4%	1.5%
of which:					
81-85	0.9%	0.3%	0.6%	0.4%	1.3%
86-90	1.0%	0.3%	0.6%	0.9%	1.9%
91-95	1.2%	0.3%	0.9%	1.0%	2.2%
96-01	1.0%	0.4%	0.6%	0.2%	1.1%
61-01	...	...	...	...	...
71-01	...	...	...	...	...
81-01	1.0%	0.3%	0.7%	0.6%	1.6%
91-01	1.1%	0.3%	0.7%	0.4%	1.5%

Source: Timmer, Ypma, and van Ark (2003) and authors' calculations.

Table 1C. Growth Accounting: Adjusting for Compositional and Factor Quality Changes

Looking at contributions to growth...

	Labor	Capital	Capital: IT	Capital: Non-IT	TFP	Value Added
81-85	0.7%	0.9%	0.2%	0.6%	-0.1%	1.4%
86-90	0.8%	0.9%	0.3%	0.6%	1.1%	2.9%
91-95	-0.2%	0.5%	0.1%	0.4%	0.9%	1.2%
96-01	0.9%	0.9%	0.3%	0.6%	0.3%	2.1%
81-01	0.6%	0.8%	0.2%	0.5%	0.5%	1.9%

Source: Bassanetti and others (2004) and authors' calculations.

Looking at capital deepening...

	Capital Deepening	Capital Quality Changes	Labor Quality Changes	Output Composition	TFP	Labor Productivity
81-85	0.6%	0.2%	0.5%	0.0%	-0.1%	1.3%
86-90	0.6%	0.2%	0.3%	-0.1%	1.1%	2.1%
91-95	0.7%	0.0%	0.5%	0.0%	0.9%	2.1%
96-01	0.4%	0.2%	0.1%	-0.1%	0.3%	1.0%
81-01	0.6%	0.1%	0.4%	0.0%	0.5%	1.6%

Source: Bassanetti and others (2004) and authors' calculations.

Table 2. Italy's Business Cycle Properties (1963q1–2001q2) [1]

	Standard deviation		Cross-correlation with GDP (t+k)									Leading indicator
	Absolute	Relative to GDP	-4	-3	-2	-1	0	1	2	3	4	P-value
International business cycle:												
Canada	1.39	1.03	-0.22	-0.10	0.06	0.24	0.39	0.47	**0.48**	0.41	0.30	**0.00**
Euro area	0.99	0.74	-0.10	0.15	0.45	0.70	0.84	0.83	0.66	0.40	0.12	**0.00**
Japan	1.43	1.06	0.21	0.25	0.30	0.35	0.39	0.43	**0.44**	0.41	0.32	**0.00**
UK	1.36	1.01	-0.26	-0.14	0.00	0.15	0.28	0.38	0.43	**0.45**	0.43	**0.01**
US	1.53	1.13	-0.45	-0.32	-0.13	0.08	0.27	0.41	0.50	**0.52**	0.48	**0.00**
Gross value added by industry:												
Agric., hunting, fishing, forestry	3.07	2.28	0.06	-0.02	-0.02	0.05	0.14	0.13	0.05	-0.06	-0.15	0.32
Construction	2.08	1.54	0.46	0.48	0.46	0.39	0.26	0.07	-0.13	-0.28	-0.36	**0.01**
Manufacturing	3.32	2.46	-0.39	-0.10	0.28	0.64	0.85	0.83	0.64	0.35	0.07	**0.00**
Retail and trade	0.51	0.38	-0.07	0.05	0.21	0.33	0.37	0.29	0.13	-0.05	-0.19	0.76
Transport and communication	1.52	1.13	0.00	0.32	0.65	0.87	0.90	0.69	0.35	0.00	-0.25	0.11
Financial int. and real estate	1.07	0.80	-0.22	-0.07	0.12	0.30	0.42	0.47	0.44	0.35	0.25	0.11
Capacity indicators:												
Industrial turnover	3.63	2.70	-0.15	0.07	0.32	0.54	0.68	0.65	0.51	0.30	0.08	**0.00**
Capacity utilization	1.76	1.31	-0.19	0.09	0.40	0.66	0.81	0.80	0.65	0.44	0.22	**0.03**
Hours worked per empl. in b.s.	0.56	0.42	0.09	0.18	0.27	0.35	0.40	**0.42**	0.40	0.34	0.26	**0.00**
Industrial production index	3.03	2.25	-0.27	0.05	0.42	0.73	0.90	0.85	0.62	0.31	0.02	**0.00**
Labor productivity in b.s	1.46	1.08	-0.23	0.06	0.43	0.75	0.92	0.87	0.63	0.30	0.01	**0.09**
Total labor productivity	1.22	0.90	-0.27	0.03	0.40	0.73	0.91	0.86	0.62	0.30	0.02	0.47
Employment indicators:												
Dependent employment in b.s.	0.89	0.66	0.49	0.60	0.66	0.65	0.56	0.39	0.19	-0.01	-0.18	**0.01**
Self employment	1.04	0.77	0.06	0.06	0.04	0.00	-0.06	-0.11	-0.13	-0.12	-0.08	0.44
Total employment in b.s.	0.66	0.49	0.44	0.53	0.56	0.53	0.42	0.25	0.08	-0.08	-0.19	0.66
Unemployment rate	0.39	0.29	-0.25	-0.20	-0.15	-0.09	-0.04	0.00	0.05	0.08	0.10	0.74
Participation rate	0.32	0.23	0.27	0.42	0.53	0.54	0.45	0.28	0.08	-0.08	-0.18	1.00
Labor force	0.49	0.37	0.19	0.37	0.50	0.54	0.46	0.30	0.11	-0.06	-0.15	0.96
Female labor force	1.33	0.98	0.23	0.43	0.56	0.56	0.48	0.32	0.16	0.02	-0.08	0.71
Male labor force	0.57	0.43	0.34	0.52	0.64	0.67	0.60	0.43	0.22	0.04	-0.07	0.27

[1] The table reports the standard deviation of the cyclical component of each series (first column) and the ratio between the standard deviation of the filtered series and that of the cyclical component of GDP (second column). Cross-correlations between x_t and y_{t+k} are given from third to penultimate column, where x_t is the transformed series of interest and y_{t+k} is the k-quarter lead of the cyclical component of real GDP. A maximum correlation at k>0 indicates that the series tend to lead the aggregate business cycle by k quarters (and is therefore reported in the table in bold font). Finally, the last column checks whether a candidate series is a leading indicator by reporting the probability of the joint hypothesis that four quarterly lags of the series are nil in a regression explaining current output, given four lagged values of the latter (values in bold font indicate here rejection of the null hypothesis at 5 percent significance level).

Table 3. Real-Time Estimates from Unobserved Component Models (1960q1–2004q2)[1, 2]

Parameters	Technology		Technology + Capacity Utilization		Technology + Capacity Utilization + Estimated Labor Share	
$\sigma_\varepsilon^{\psi ip}$	.009	(.001)	.009	(.001)	.0090	(.001)
$\sigma_\varepsilon^{\psi a}$	**.007**	**(.001)**	**.001**	**(.003)**	**.001**	**(.004)**
$\sigma_\nu^{\mu a}$	0	(--)	0	(--)	0	(--)
$\sigma_\omega^{\kappa a}$	**.001**	**(.000)**	**.001**	**(.000)**	**.000**	**(.000)**
$\sigma_\varepsilon^{\psi pr}$	.004	(.000)	.004	(.000)	.004	(.000)
$\sigma_\nu^{\mu pr}$	0	(--)	0	(--)	0	(--)
$\sigma_\omega^{\kappa pr}$	.001	(.000)	.001	(.000)	.001	(.000)
$\sigma_\varepsilon^{\psi u}$	.002	(.000)	.002	(.000)	.002	(.000)
$\sigma_\nu^{\mu u}$	0	(--)	0	(--)	0	(--)
$\sigma_\omega^{\kappa u}$	.001	(.000)	.001	(.000)	.001	(.000)
$\sigma_\varepsilon^{\psi h}$	.004	(.000)	.004	(.000)	.004	(.000)
$\sigma_\nu^{\mu h}$	0	(--)	0	(--)	0	(--)
$\sigma_\omega^{\kappa h}$	.002	(.000)	.002	(.000)	.002	(.000)
φ_1	1.276	(.065)	1.255	(.079)	1.255	(.076)
φ_2	-.407	(.041)	-.375	(.066)	-.375	(.073)
τ^a_0	**.631**	**(.077)**	**.306**	**(.081)**	**.316**	**(.090)**
τ^a_1	**-.156**	**(.074)**	**-.014**	**(.023)**	**-.017**	**(.050)**
τ^{pr}_0	.046	(.046)	.046	(.046)	.046	(.046)
τ^{pr}_1	.065	(.045)	.065	(.045)	.065	(.045)
τ^u_0	-.040	(.021)	-.040	(.022)	-.040	(.027)
τ^u_1	.024	(.022)	.024	(.014)	.024	(.022)
τ^h_0	.001	(.073)	.001	(.038)	.001	(.028)
τ^h_1	-.083	(.058)	-.083	(.054)	-.083	(.053)
$1-\beta$	.337	--	.337	--	.386	(.178)
Log-likelihood	**3075.86**		**3091.30**		**3092.55**	
SEE	**0.93%**		**0.86%**		**0.85%**	
AR(5)	**3.36**	**[0.01]****	**1.24**	**[0.29]**	**1.22**	**[0.30]**
$\Delta y^*_{t+1\|t}$	1.25%		1.25%		1.25%	
$y^c_{t+1\|t}$	-1.00%		-1.00%		-1.00%	
$NAIRU_{t+1\|t}$	8.5%		8.5%		8.5%	

[1] Standard errors are in parentheses. (--) indicates restricted estimates.
[2] P-values are provided in square bracket.

Figure 1. Italy: Labor Force Statistics

Source: OECD.

Figure 2A. Adjusting TFP for Compositional and Quality Changes in Capital

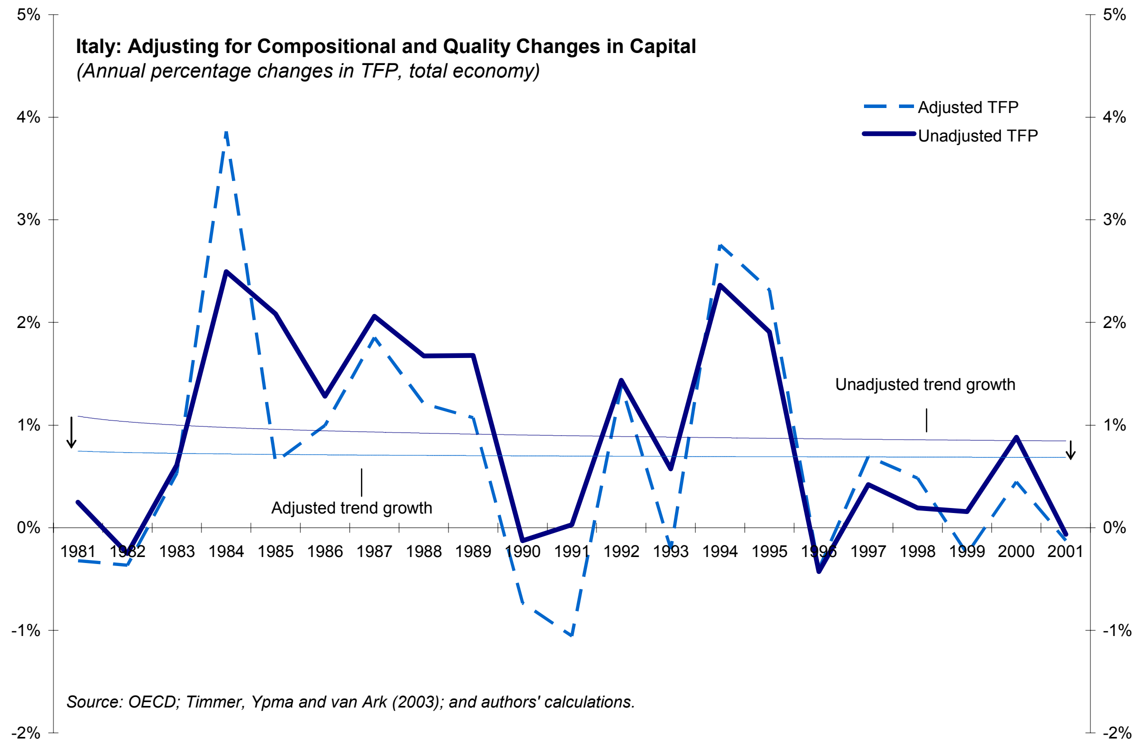


Figure 2B. Adjusting TFP for Compositional and Quality Changes in Labor

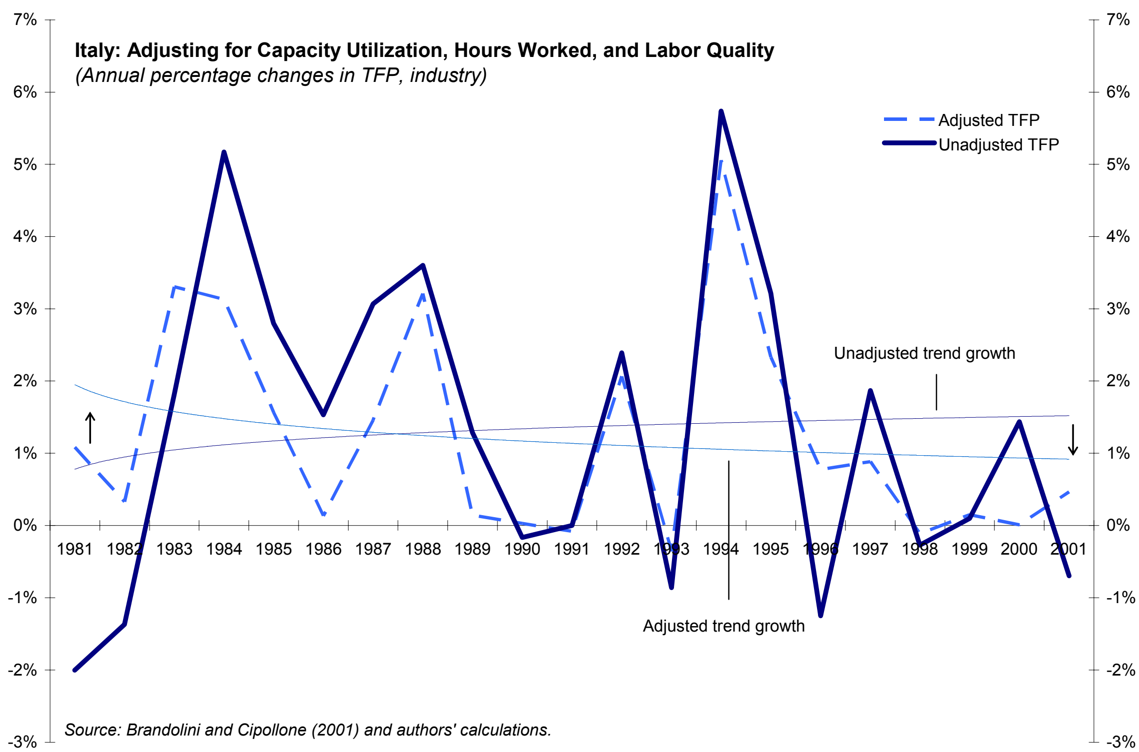


Figure 3A. Adjusting TFP for Cyclical Factors

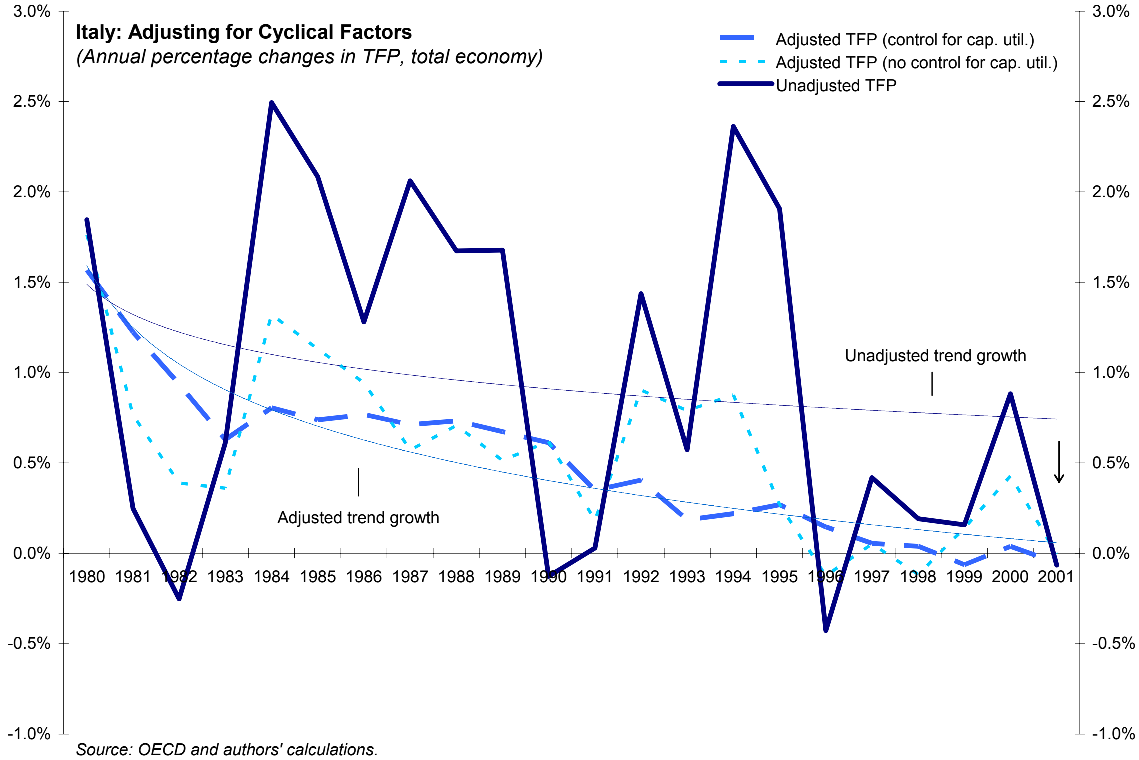


Figure 3B. Potential and Cyclically Adjusted TFP Growth

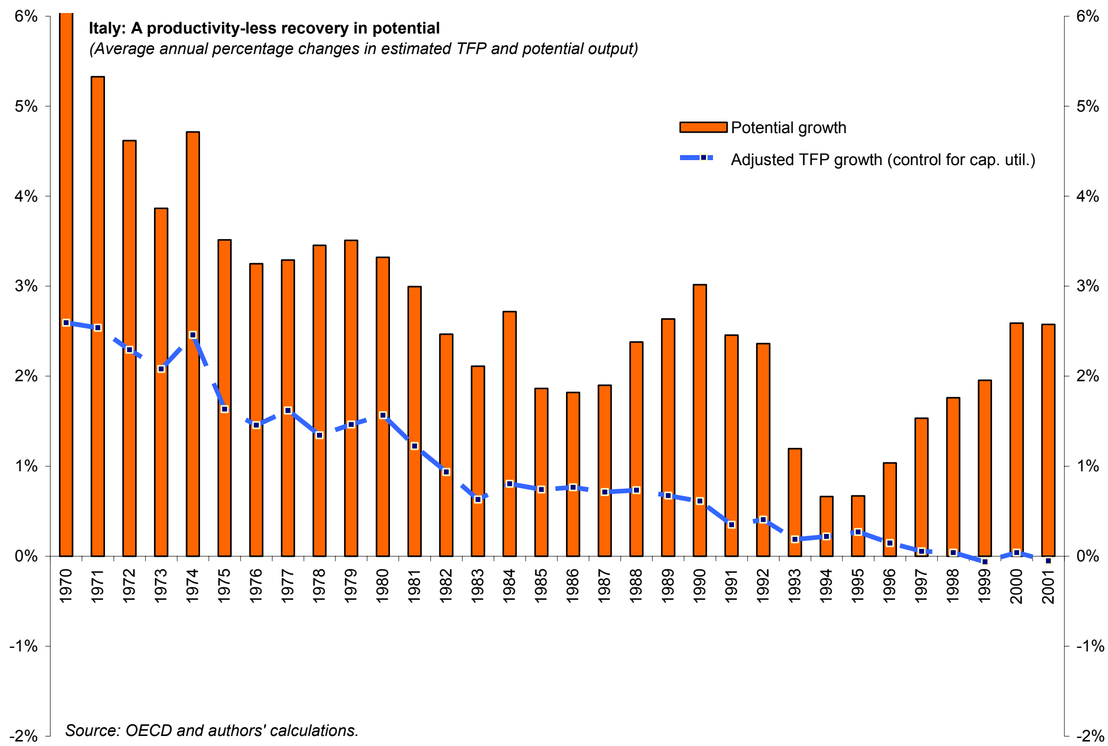


Figure 4. One-Step Ahead Forecast Errors Controlling for Capacity Utilization

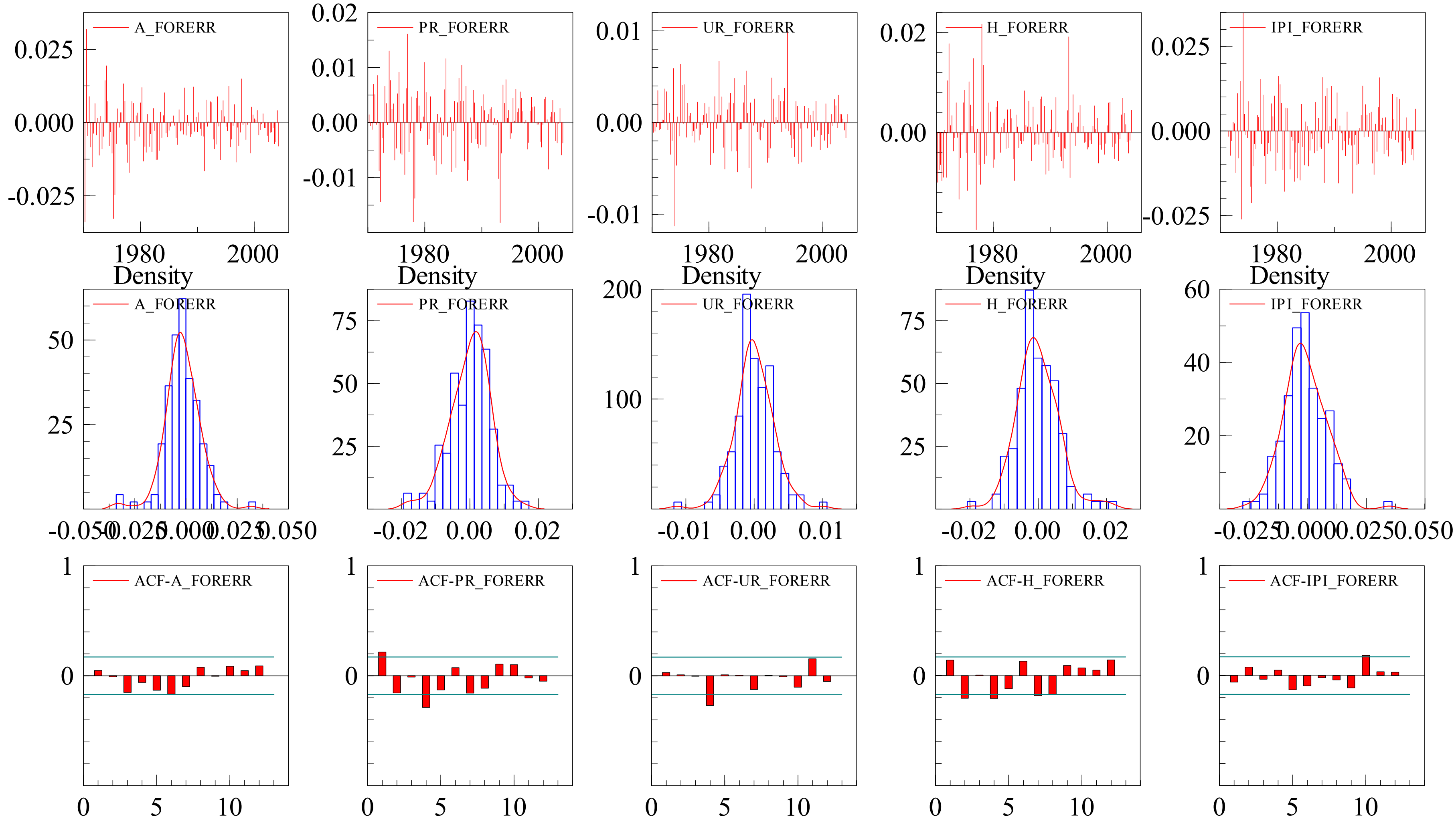


Figure 5. Response to Cholesky One S.D. Innovations to Permanent Components

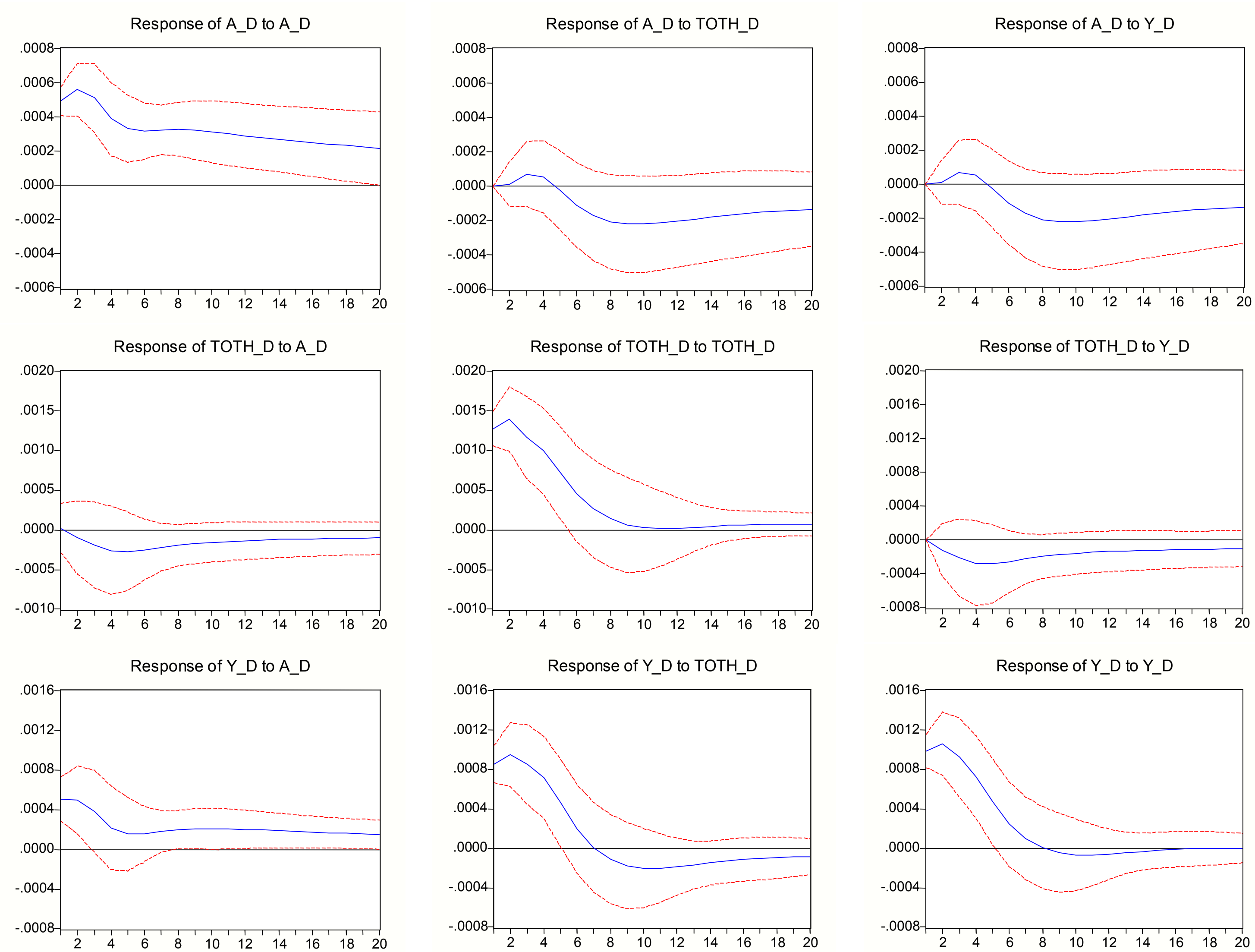


Figure 6. Response to Cholesky One S.D. Innovations to Transitory Components

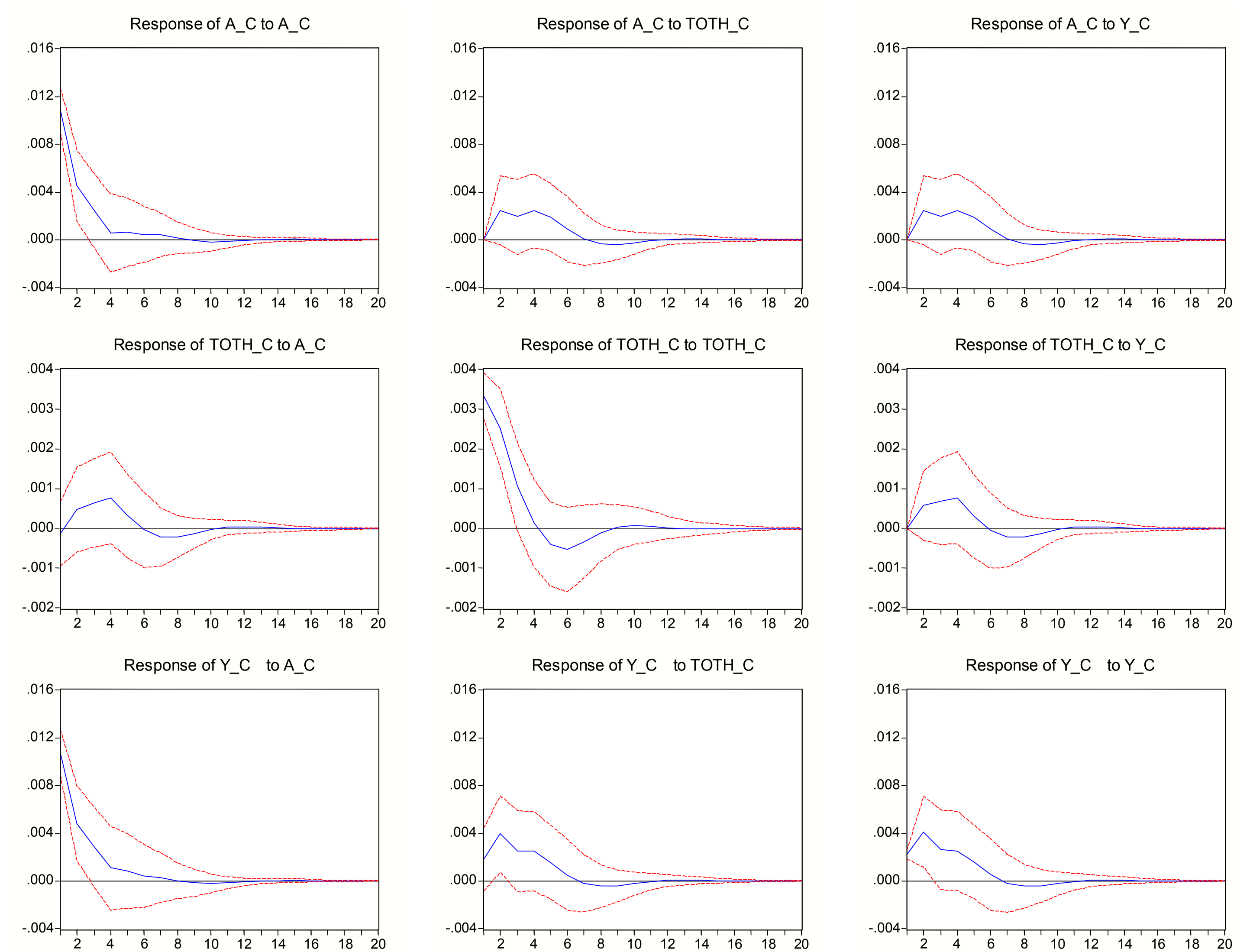


Figure 7. Potential Growth Variance Decomposition

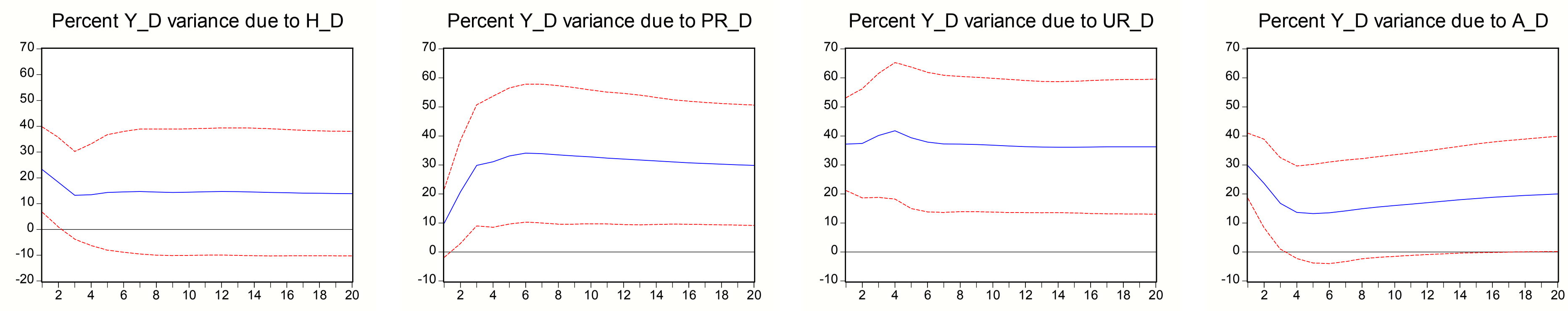
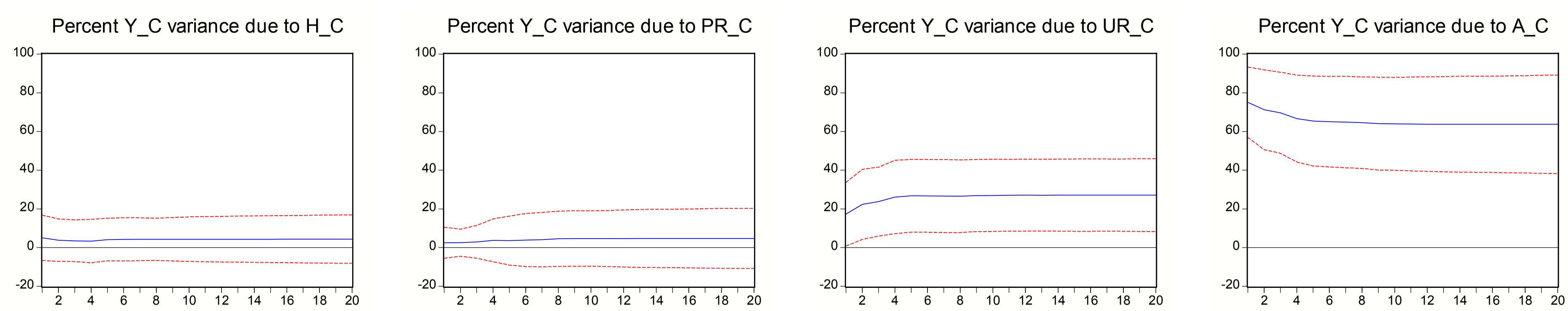


Figure 8. Business Cycle Variance Decomposition



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